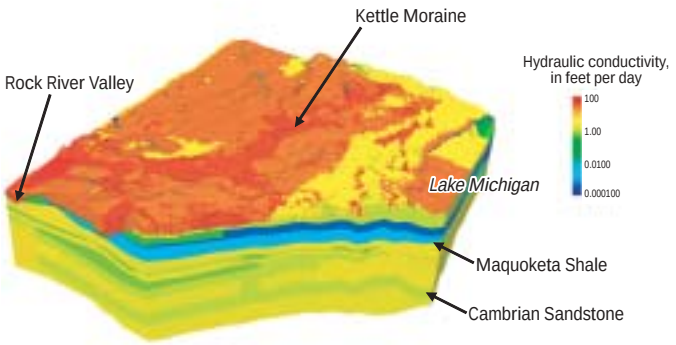
GROUND-WATER SYSTEMS TEAM

Mission

The mission of the Ground-Water Systems Team is to provide a pool of expertise in a variety of disciplines from which flexible and dynamic sub-teams are formed to conduct District projects. The team serves as a forum in which participating members are kept abreast of new techniques and approaches in ground-water research and investigations. The team provides technical review for existing ground-water projects and designs and presents proposals to cooperators. Team membership fosters a close working relationship with cooperators and the University community. The team provides cooperators with state-of-the-art techniques and expertise to provide an understanding of ground-water systems and its relationship to natural resources and man.

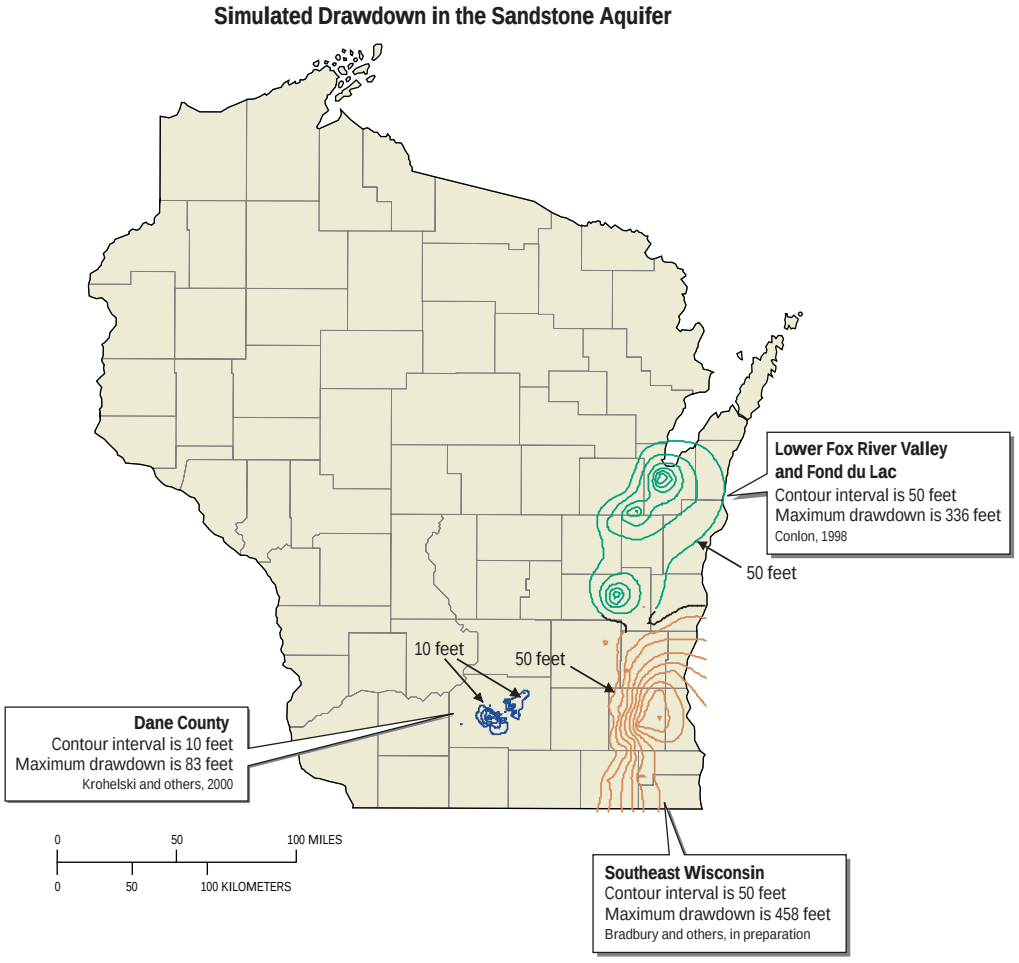
Team Members

James T. Krohelski, Hydrologist
Randy J. Hunt, Research Hydrologist/Geology
Charles P. Dunning, Physical Scientist
David A. Saad, Hydrologist/Geology
Daniel T. Feinstein, Hydrologist
James M. Rauman, Hydrologic Technician
Cheryl A. Buchwald, Hydrologic Technician
Paul F. Juckem, Student Trainee (Hydrology)
Gregory D. Mueller, Hydrologic Technician



Southeast Wisconsin Ground-Water Flow Model

PROJECTS



Results from three ground-water flow models show extensive water-level declines from pre-development conditions. Large ground-water withdrawals from the Green Bay (green) and Milwaukee metropolitan (orange) areas have resulted in extensive cones of depression that have coalesced and extend past the Illinois border (not shown). The declines are large because the aquifer is confined and water is obtained from leakage from overlying rock units, lateral flow from distant sources, and aquifer storage. The Dane County cone of depression (shown in blue) is smaller in extent because withdrawals are primarily being fed by local sources of water (such as lakes, streams, and wetlands) that are in direct contact with the aquifer.

CRANDON GROUND WATER

COOPERATOR:

Wisconsin Department of Natural Resources

PROJECT CHIEF:

James T. Krohelski

LOCATION:

Forest County

PROJECT NUMBER:

WI 00201

PERIOD OF PROJECT:

October 1994–Continuing

PROBLEM

A large underground zinc-copper mine is being proposed at a site about five miles south of Crandon, Wisconsin, in Forest County. The Wisconsin Department of Natural Resources (WDNR) requested that District staff review the development of a ground-water-flow model and associated hydrologic documents as part of a permitting process for the proposed mine.

OBJECTIVE

The objective is to review documents related to water resources submitted to WDNR from the Nicolet Minerals Company and their consultants; and to make suggestions to WDNR on studies and approaches that will improve the understanding of the hydrology and effects of mining on the water resources in the vicinity of the proposed mine.

APPROACH

The schedule for review of documents will be mutually agreed upon between WDNR and USGS.

PROGRESS (July 2001 to June 2002)

The Technical Working Group's draft report for the ground-water- flow model was completed. A review of the TMA and Reflooded mine contaminant transport models was continued. Monitoring of lake stage and shallow ground-water levels adjacent to Little Sand Lake and Skunk Lake were continued.

PLANS (July 2002 to June 2003)

Documents will be reviewed and meetings attended at the request of the WDNR. Complete the Technical Working Group's report for the ground-water-flow model. A review of the TMA and Reflooded mine contaminant transport models will be continued. Monitoring of lake stage and shallow ground-water levels adjacent to Little Sand Lake will be continued.

SIMULATION OF SHALLOW GROUND-WATER FLOW ON THE STOCKBRIDGE MUNSEE INDIAN RESERVATION WITH THE USE OF AN ANALYTIC ELEMENT MODEL

COOPERATOR:

Stockbridge-Munsee Band of Mohican Indians

PROJECT CHIEF:

Charles P. Dunning

LOCATION:

Stockbridge-Munsee Reservation

PROJECT NUMBER:

WI 12307

PERIOD OF PROJECT:

January 2002 to September 2003

PROBLEM

The Stockbridge-Munsee Indian Tribe of northeastern Wisconsin is interested in increasing their understanding of regional ground-water flow across the reservation. This understanding can be applied to a variety of water management needs, and will enable the Tribe to make informed decisions about water quantity and quality issues.

OBJECTIVE

The objective of this study is to develop an understanding of the regional ground-water flow system across the Stockbridge-Munsee Indian Reservation, and to provide the Tribe a tool to investigate a wide range of water resource problems.

APPROACH

Water supply for the Stockbridge-Munsee Indian Reservation is provided primarily by wells completed in unconsolidated glacial sediments. Numerous methods and approaches are available for investigating ground-water flow, ranging from simple analytical techniques to sophisticated computer modeling (U.S. Environmental Protection Agency, 1994; Blandford and others, 1994; Haitjema and others, 1994). The relatively uncomplicated nature of the glacial sediment aquifer on the reservation suggests that a single-layer, steady state Analytic Element (AE) ground-water-flow model will be appropriate to simulate the ground-water flow system.

The AE model code GFLOW (Mitchell-Bruker and Haitjema, 1996) will be used to simulate the ground-water/surface-water system across the Stockbridge-Munsee Reservation. Once the model is calibrated to measured ground-water levels and stream flows it can be used to simulate and plot the direction of ground-water flow and ground-water travel time. The results of this study will provide the Tribe with a water resources management tool that will help assess the fate and transport of contaminants and provide the necessary information to plan well-head protection strategies for the community well systems. The Tribal staff will benefit from this study by learning appropriate techniques to determine contributing areas and time of travel. The

study will help determine areas where future data collection may be needed to understand the complexities of the ground-water-flow system.

PROGRESS (July 2001 to June 2002)

Hydraulic detail has been added to the regional GFLOW model around the Stockbridge-Munsee reservation area. Hydraulic head and stream flow targets have been compiled and added to the model. Additional stream flow measurements were taken at several locations across the reservation. Model calibration is ongoing, and the model is being used to address a number of water management issues.

PLANS (July 2002 to June 2003)

The GFLOW model will be used to evaluate current water management issues of the Stockbridge-Munsee tribe. A report will present results of the study and an interpretation of the shallow ground-water-flow system across the reservation. The report will also document model construction and calibration.

CHARACTERIZATION OF THE REGIONAL AQUIFER FLOW-SYSTEM ON THE MENOMINEE INDIAN RESERVATION

COOPERATOR:

Menominee Indian Tribe of Wisconsin

PROJECT CHIEF:

Charles P. Dunning

LOCATION:

Menominee County

PROJECT NUMBER:

WI 12312

PERIOD OF PROJECT:

October 1998–Continuing

PROBLEM

The Menominee Indian Tribe is interested in determining the contributing areas and time of travel for water captured by wells for a number of community water systems in Menominee County, Wisconsin. The Tribe's interest in well-head protection is heightened over concern about the presence of elevated nitrate levels in several wells.

OBJECTIVE

The objective of the study is to determine the contributing areas and time of travel for water captured by community wells. This information will be used by the Menominee Indian Tribe for water resource and well-head protection planning in community areas.

APPROACH

The USGS will construct a simple one-layer ground-water model to simulate the hydrologic conditions in an appropriate area around community wells. The ground-water model will be used to delineate the zone of ground-water contribution to the wells for 5-, 10- and 100-year times of travel, and define the associated area of contribution. The results of these investigations will provide the Tribe with the necessary information to plan a well-head protection strategy for each community system.

PROGRESS (July 2001 to June 2002)

The reservation-wide analytic element model has been in the process of calibration. Assistance was provided to the Menominee Indian Tribe in identifying locations around Zoar that will avoid the elevated nitrate found in the current wells. As a result, a location meeting all the requirements has been identified. Field activities for the hydrogeologic study around the town of Neopit were completed, though some stream gaging continues periodically. The results and interpretation of the Neopit study focusing on the community wells and the sewage treatment lagoons is being finalized. A new investigation has been undertaken to locate favorable locations for new municipal wells in the town of Keshena. The regional ground-water-flow model was used in

this investigation to identify locations around Keshena that would likely be free of septic or contamination sources.

PLANS (July 2002 to June 2003)

The USGS drill rig will be used to investigate the depth to bedrock and saturated thickness of potential sites around Keshena. Specific ground-water-flow modeling is underway at three other communities on the Reservation—Middle Village, Onekewat, and Redwing. Results of these investigations will be presented as Water-Resources Investigation Reports.

MONITORING CONTAMINANT FLUX FROM A STORMWATER INFILTRATION FACILITY TO GROUND WATER

COOPERATOR:

Wisconsin Department of Natural Resources

PROJECT CHIEF:

Charles P. Dunning

LOCATION:

Dane County

PROJECT NUMBER:

WI 17238

PERIOD OF PROJECT:

July 2001 to July 2003

PROBLEM

Wisconsin is in the process of finalizing administrative code NR 151 which will in part define performance standards for infiltration of stormwater from new development. The stormwater infiltration standards are intended to preserve ground-water recharge and stream baseflow. However, depending on the characteristics of a drainage area, infiltration of stormwater may introduce significant amounts of contaminants to ground water including hydrocarbons, pesticides, bacteria, and chloride. Because of the impending performance standards for infiltration, it is imperative to quantify the relation between quality of infiltrated stormwater and the flux of contaminants to the ground-water system.

OBJECTIVE

The objective of the proposed study is to quantify through field data the relation between the quality of infiltrated stormwater and the flux of contaminants through the unsaturated zone to ground water.

APPROACH

Following preliminary investigation at sites in central Dane County, it has been decided to focus on two sites in the city of Middleton. One site is an infiltration basin that serves Stonefield, a residential neighborhood, and has been in place for about 10 years. The other is an infiltration trench installed next to a new parking lot that is a part of the expansion of the Middleton High School. At these two sites, a small diameter water-table monitoring well will be installed to observe the specific relation between stormflow events and the elevation of the water table. The use of an equilibrium-tension lysimeter at these sites has been abandoned in favor of porous cup suction lysimeters, because of the need to be able to change the vertical location of sampling points in response to insight gained as the project progresses. During installation of monitoring wells we expect to characterize the soil and moisture profiles of each site. This information will be used in choosing initial installation points for lysimeters in the vadose zone. The disadvantage of the new approach is that it will be more difficult to infer with precision the hydrologic balance

of stormflow infiltration and/or mass-balance of contaminants than would have been possible with the equilibrium-tension lysimeter. Monitoring and sampling of lysimeter leachate, stormwater and ground water will be carried out using a combination of automated and manual means. Data gathered over the course of this study will be compiled and interpreted to characterize the flux of infiltrated contaminants to ground water. The relation between stormwater quality and contaminant flux will be evaluated.

PROGRESS (July 2001 to June 2002)

At the Stonefield Neighborhood site a soil boring has been completed to a depth of 30 feet, and reveals a change from soil and clay at the top of the section to dry, clean, fine sand at the bottom. The dry sand prevented deeper penetration with the Geoprobe. This boring will be extended to the water table with rotary augers and a pressure transducer will be installed to monitor ground water levels. A slotted standpipe was installed at the control structure that provides outflow from the infiltration basin to the stormwater sewer system. This standpipe allows the measurement of pond stage during stormwater events. Data have been compiled for the period from the April installation of the standpipe to present (data continue to be collected).

Preliminary interpretation of data suggests that changes in barometric pressure are observed in both the transducer monitoring barometric pressure and the transducer monitoring water level in the standpipe. The difference between values measured by these two transducers represents the pressure due to standing water over the transducer in the standpipe (pond stage). Temperature data suggest that a measurable rise in water temperature in the standpipe occurs with each stormwater event. Preliminary data also suggest that even a moderate rainfall (0.5 inches or less) will result in significant ponding within the infiltration basin, generally from about 1 to 2 feet deep though as deep as about 4.5 feet. It must be kept in mind however, the reported depth of rainfall is for Madison in general and the actual depth of precipitation over the contributing area to the Stonefield infiltration basin will likely be somewhat different. Following ponding in the basin a combination of leakage between stop planks at the control structure to the stormflow system and the infiltration well will cause the stage to drop rapidly. Once the level drops to about the basin bottom the rate at which the water level drops much more slowly.

At the Middleton High School site a pressure transducer has been installed in a standpipe in the infiltration trench. Monitoring of water level in the trench resulting from stormflow events began March 28, 2002.

PLANS (July 2002 to June 2003)

During selected stormwater events water-quality samples will be taken of the stormwater, leachate from the unsaturated zone, and water table. Initial water-quality samples will serve to check the integrity of the lysimeters and well points, and provide a measure of initial contaminant concentrations. Water-quality sampling may be conducted at regular time intervals, in response to an infiltration event, or in both instances. Data will be compiled, interpreted, and summarized in a report to the Wisconsin Department of Natural Resources.

POOL 8 GROUND-WATER/SURFACE-WATER STUDY

COOPERATORS:

U.S. Geological Survey,
Water Resources Discipline
National Stream Quality Accounting
Network Program
U.S. Geological Survey,
Biological Resources Discipline

PROJECT CHIEF:

Randy J. Hunt

LOCATION:

Southwestern Wisconsin

PROJECT NUMBER:

WI 17304

PERIOD OF PROJECT:

May 1999 to October 2002

PROBLEM

Nitrogen loading and transformation in the Upper Mississippi River (UMR) system has recently become an issue of concern. The influence of ground water on the loading and transformation is poorly known, primarily due to the difficulty in quantifying the location and magnitude of ground-water/surface-water interaction and nitrogen concentrations within the ground water. The interactions of ground water and surface water, however, may influence the nitrate chemistry in the Upper Mississippi River system.

OBJECTIVE

The project objectives are to: (1) determine magnitude of ground-water discharge and nitrate loading via ground water to the Pool, and (2) delineate important contributing areas for the Pool.

APPROACH

The investigation is conducted using a stepwise approach where a model was developed using existing data. Results of the initial model were then used to guide future data collection, which was used to update the model. The initial ground-water-flow model was constructed using analytic element methods. Different system conceptualizations were tested by coupling the analytic element model to a parameter estimation code. The field work included on-shore installation of permanent well nests to characterize the local and regional ground-water systems and collection of ground-water samples for nutrient analyses. The analytic element model was translated to a three-dimensional model using the finite-difference code MODFLOW. The resulting three-dimensional model and geochemical sampling will be used to construct maps of ground-water discharge, flowpaths, and travel times.

PROGRESS (July 2001 to June 2002)

Groundwater level data collection has continued. A three-dimensional MODFLOW model has been extracted from the analytic element model and calibrated to the ground-water-level data and streamflow data. Ground-water discharge zones and magnitude of

ground-water flux and associated nitrate loading were determined using the calibrated model.

PLANS (July 2002 to June 2003)

A Water-Resources Investigations Report will be published describing the model construction and results.

Flooding on Goose Island.

Pool 8 shoreline.

HYDROLOGIC INVESTIGATION OF SILVER LAKE

COOPERATOR:

Silver Lake Protection and Rehabilitation District

PROJECT CHIEF:

Charles P. Dunning

LOCATION:

Washington County

PROJECT NUMBER:

WI 17305

PERIOD OF PROJECT:

October 1999 to September 2001

PROBLEM

Silver Lake is a ground-water seepage lake located in central Washington County, southeastern Wisconsin. Because of its strong hydraulic connection to the shallow ground-water-flow system, Silver Lake could be affected adversely by land-use changes in its watershed. The Silver Lake Protection and Rehabilitation District seeks a better understanding of the ground-water flow system around Silver Lake and means to evaluate the effect of land-use changes.

OBJECTIVES

Specific objectives are to: (1) determine the hydraulic parameters and budget components of Silver Lake, (2) identify key ground-water recharge areas for Silver Lake, and (3) quantify the loading to the lake due to ground-water inflow.

APPROACH

Historical hydrologic data will be used to develop a numerical ground-water-flow model of Silver Lake and its watershed. Water budget parameters to be included in the model are precipitation, evaporation, and measured water levels and flows. This model will be calibrated to lake stage and discharge as well as hydraulic heads and stream flows.

PROGRESS (July 2001 to June 2002)

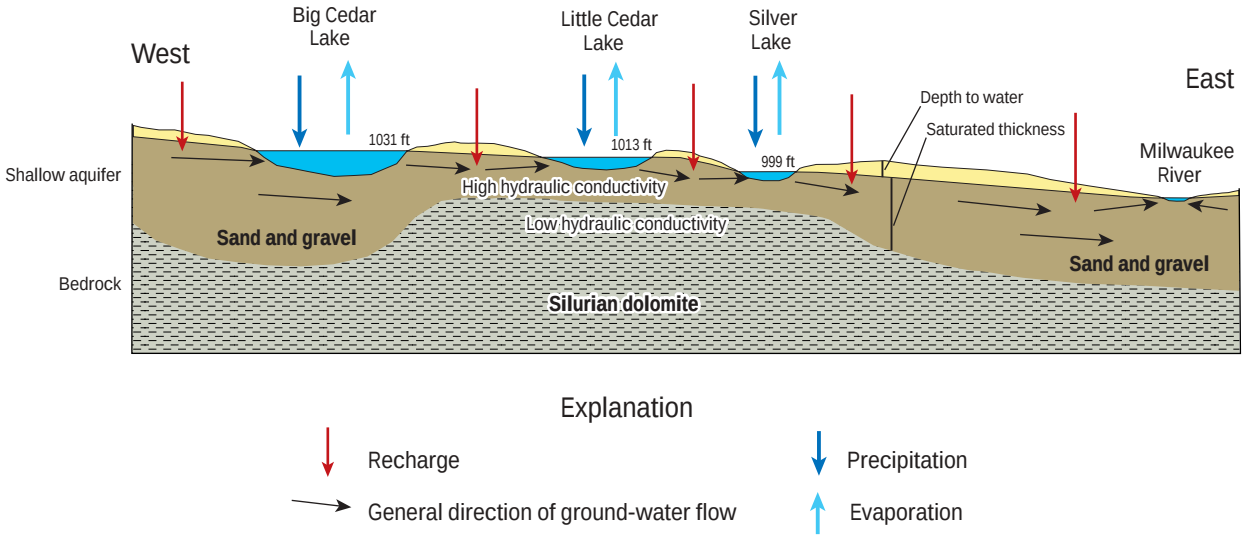
Study is complete. Report is in review. Hydraulic parameter values for the shallow aquifer have been estimated through characterization of the study area and calibration of the AE model. Based on results of the calibrated model, hydraulic conductivity of the shallow aquifer ranges from 20 to 50 ft/d, lower in the Kettle Moraine Area and greater in the surrounding areas. The rate of recharge varies from 4 to 12 in/yr, higher in the Kettle Moraine Area and lower in surrounding areas. The hydrologic budget components for Silver Lake have been determined and their values estimated. Stream flow from Silver Lake was computed as a residual in the hydrologic budget and compared to measured flows. Precipitation on the lake minus evaporation from the lake is reported in the literature to be about 0.04 ft^3/s

(3 in/yr). Model results show ground-water flow into Silver Lake is 1.08 ft^3/s, and flow from Silver Lake to the shallow aquifer is 0.08 ft^3/s. The residual of 1.04 ft^3/s is the stream flow from Silver Lake to Silver Creek and matches observed flows very well. Ground-water-recharge areas for Silver Lake have been simulated using backward tracking of particles in the AE model. Using a porosity of 20 percent, areas for times of travel of 10, 20, and 50 years were defined. Nearly all the ground water flowing to Silver Lake comes from recharge areas to the west The recharge area for the northern two thirds of Silver Lake lies west toward Big Cedar Lake, though the 50-year time of travel does not extend all the way to Big Cedar Lake. The recharge area for the southern one third of Silver Lake lies west toward Little Cedar Lake. The time of travel from Little Cedar Lake to Silver Lake is between 15 and 20 years.

The solute flux toward Silver Lake was estimated using average concentrations measured in observation wells and the simulated ground-water flux. However, in order to estimate solute mass loading to Silver Lake from ground-water discharge, it would be necessary to characterize the nature of the sediment-water interface, as well as the chemistry of the pore water in the lake littoral region (within about 1 meter of the interface). Solutes like nitrogen and phosphorous would likely be very affected by biotic and abiotic processes near the sediment-water interface.

PLANS (July 2002 to June 2003)

A Water-Resources Investigation Report will be published.



SOUTHEAST WISCONSIN GROUND WATER

COOPERATOR:

Wisconsin Geological and Natural History Survey

PROJECT CHIEF:

Daniel T. Feinstein

LOCATION:

Southeastern Wisconsin

PROJECT NUMBER:

WI 20800

PERIOD OF PROJECT:

February 1998 to September 2003

PROBLEM

Much public attention has been focused in the last several years on the problem of insuring an adequate and inexpensive supply of water to southeastern Wisconsin in the next century. The southeastern Wisconsin communities of Waukesha, Brookfield, Germantown, Menomonee Falls and Pewaukee are prohibited by the Great Lakes Charter from drawing water from Lake Michigan. Water utilities in these areas are concerned that rapidly falling ground-water levels in the sandstone aquifer indicate that water supply will not be able to keep pace with development.

OBJECTIVE

In southeast Wisconsin there is a need to construct a three-dimensional ground-water model to address circulation within the shallow and deep aquifer systems in the presence of intense pumping for water supply. The overall aims of the project are to (1) determine essential hydrogeologic parameters of the regional aquifers to permit accurate simulation of regional flows and allow better understanding of the communication between shallow and deep systems; (2) investigate flow paths under different use scenarios for purposes of delineating capture zones and wellhead protection areas, evaluating well interference, and examining ground-water/surface-water connections; and (3) permit optimization of future well placement and pumping schedules by use of submodels.

APPROACH

The water utilities need information from the USGS to decide on a regional strategy for optimizing water supply. Specifically they need a framework to decide on the spacing, number, and, perhaps most critically, the open interval. A balance is needed between relatively thin shallow aquifers that are potentially subject to surface contamination and the underlying thick sandstone aquifer that suffers from excessive drawdown, increasing salinity, and potential radium influx. Optimization depends on many factors: for example, mapping of recharge areas to the shallow system and the sandstone aquifer, evaluation of the exchange between the two systems across units such as the Maquoketa Shale, and a better understanding of the stratigraphy in the deep sandstone aquifer. A regional three-dimensional model will serve as the platform for integrating

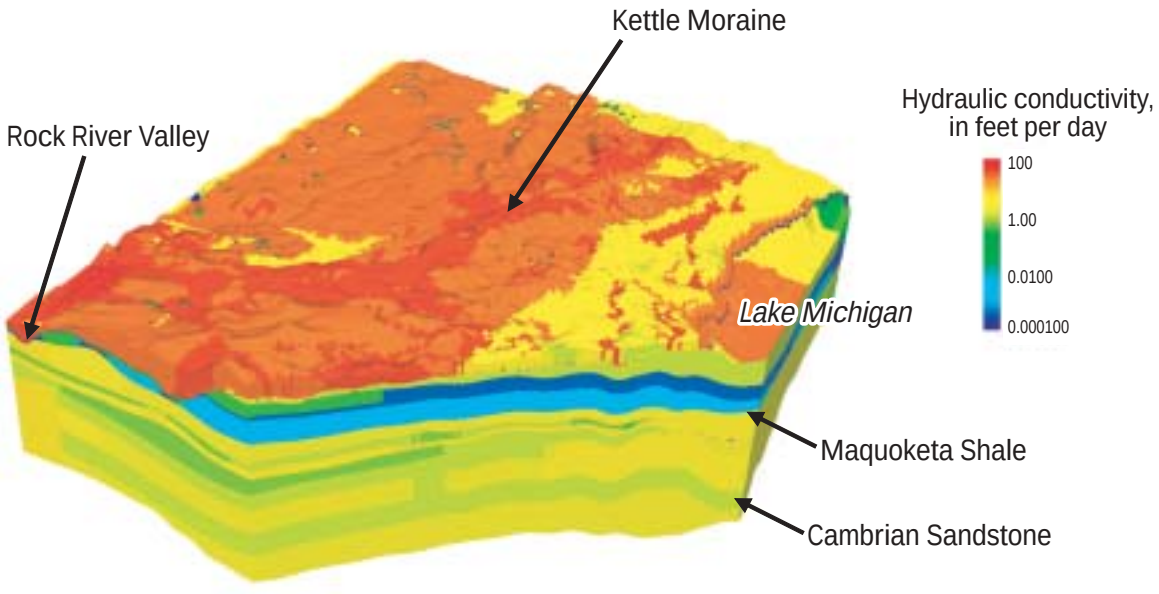
these factors. It will also serve as the tool for simulating optimization scenarios.

PROGRESS (July 2001 to June 2002)

This year we constructed and calibrated the steady-state model representing pre-development conditions, then constructed and calibrated the transient model representing the response of the shallow and deep systems to over 100 years of pumping. Tasks included: (1) insertion of water bodies, recharge zones and bedrock valleys at the top of the model, (2) zonation of horizontal and vertical hydraulic conductivity in both shallow and deep model layers, (3) preparation of calibration targets for the pre-development model including 19th century water levels in the sandstone aquifer and estimated fluxes to streams, (4) preparation of shallow and deep calibration targets for the transient model including well hydrographs, packer-test data, and location of water divides through time, (5) calibration of the pre-development model using parameter estimation methods, (6) tabulation of water use from the late 19th century to the present in both the shallow and deep systems, (7) calibration of the transient model to match long-term trends in observed drawdown throughout the study area, (8) analysis of model results with emphasis on the spatial distribution of sources of water to wells, (9) preparation of a report (published by the Wisconsin Geological and Natural History Survey) summarizing model construction, calibration and results, and (10) cooperation with groups interested in constructing local inset models extracted from the regional model.

PLANS (July 2002 to June 2003)

The remaining work on the project involves delineation of capture zones to define well-head protection and development of optimization scenarios to guide management of the ground-water resource. These products will be issued in a report. Efforts to refine and improve the model will continue in order to account for features such as abandoned wells and the Milwaukee Deep Tunnel. Public outreach including possible web-based projects will be undertaken.



Southeast Wisconsin Ground-Water Flow Model

REGIONAL HYDROGEOLOGIC STUDY OF LA CROSSE COUNTY

COOPERATORS:

Wisconsin Department of Natural Resources, and
Wisconsin Geological and Natural History Survey

PROJECT CHIEF:

Randy J. Hunt

LOCATION:

La Crosse County

PROJECT NUMBER:

WI 21900

PERIOD OF PROJECT:

July 2000 to October 2002

PROBLEM

Ground water is the sole source of residential water supply in La Crosse County. Approximately 75 percent of the residents are served by municipal water systems located along the Mississippi or Black Rivers, which withdraw ground water from an alluvial aquifer. The alluvial aquifer is susceptible to contamination because of its proximity to surface water and lack of an areally extensive protective confining unit. Presently, there are over 120 ground-water contamination sites in La Crosse County, mostly in the vicinity of the cities of La Crosse and Onalaska. Knowledge of the regional ground-water system is needed in order to understand the sources of ground water for both the bedrock and alluvial fill aquifers.

OBJECTIVE

The purpose of the study is to understand and characterize the regional ground-water-flow system, as well as the local water resources around population centers. Specific objectives are as follows: collect, compile and analyze data to characterize the regional ground-water-flow system and form a conceptual hydrogeologic model; quantitatively identify the zone of contribution for each municipal ground-water supply system in the county using numerical modeling techniques; and encourage water-resource management and protection by introducing and promoting the use of study products through educational and outreach efforts in La Crosse County.

APPROACH

Existing information regarding the spatial distribution and hydraulic properties of hydrogeologic units and water-use data will be compiled. A three-dimensional model will be developed based on conceptual and initial analytic element screening models. Additional field data will be collected in areas requiring better definition or resolution of hydraulic parameters or to provide more complete coverage of water levels or streamflows. The model will be calibrated by comparing simulated ground-water levels and streamflows to measured values. Zone of contributions for the 68 municipal supply wells within the county will be delineated using particle tracking and selected management scenarios will be simulated.

PROGRESS (July 2001 to June 2002)

Ground-water-level, streamflow, and precipitation data collection has continued. A deep observation well has been drilled and undergone geophysical and hydrologic testing in cooperation with the Wisconsin Geological and Natural History Survey. A three-dimensional MODFLOW model has been extracted from the analytic element model and calibrated to the ground-water-level data and streamflow data.

PLANS (July 2002 to June 2003)

A Water-Resources Investigations Report will be published describing the model construction and results.

Flooding near Riverside Park, La Crosse, April 2001.

SUSCEPTIBILITY OF LA CROSSE MUNICIPAL WELLS TO ENTERIC VIRUS CONTAMINATION FROM SURFACE WATER CONTRIBUTIONS

COOPERATOR:

Marshfield Medical Research Foundation

FUNDING AGENCY:

Wisconsin Department of Natural Resources Groundwater Management Practice Monitoring Program

PROJECT CHIEF:

Randy J. Hunt

LOCATION:

City of La Crosse

PROJECT NUMBER:

WI 21901

PERIOD OF PROJECT:

March 2001 to September 2002

PROBLEM

Viruses derived from surface water are potential contaminants because they can move readily through the soil due to their extremely small size and negative charge at typical soil pH levels. Data on the extent and temporal nature of virus contamination of water-supply wells are limited because the techniques are expensive and specialized.

OBJECTIVE

Project objectives are: (A) document the presence of viruses in water-supply wells that have varying amounts of surface-water components, (B) assess the temporal nature of virus occurrence, (C) quantify the amount of surface water present in the well discharge and determine the time of travel, and (D) relate C to A and B.

APPROACH

Particle-tracking identified three classes of water-supply wells: (1) those that are expected to have high surface water contributions, (2) those that have intermediate surface water contributions, and (3) those that are expected to have little or no surface water contributions. The sampling includes a surface water source, two wells of the first class of wells, and one well in each of the latter two classes, for a total of five samples per sampling period. Because of the transient nature of virus occurrence, the sites will be sampled frequently over time (12 times per year). Biological analyses will include reverse transcription—polymerase chain reaction (RT-PCR) for detecting human enteric viruses and analyses for microbiological indicators of water sanitary quality. In addition, water analyses will include water isotopes ($^{18}O/^{16}O$, $^{2}H/^{1}H$) to identify amounts of

surface water, and water tracers to date the age of the water.

PROGRESS (March 2001 to June 2002)

Samples have been collected monthly from March 2001 through February 2002. Virus and indicator analyses are ongoing. Water isotope sampling indicates detectable surface water contribution in two of the four wells. Two additional monitoring wells were installed between the surface water source and the adjacent municipal wells to collect water samples specific to the surface water source rather than a bulk average of all the flow that enter the well. The new wells were sampled for water isotopes, viruses, and age-dating using CFCs and ^{3}H-^{3}He. In addition to continuing monthly virus, indicator, and water isotope sampling until February 2002, methodology for improving the virus test sensitivity is being evaluated.

PLANS (March 2002 to September 2002)

Analyses will be completed and a report written detailing the findings of the work.

Virus filtering apparatus near La Crosse well 24.

REGIONAL HYDROGEOLOGIC STUDY OF SAUK COUNTY, WISCONSIN

COOPERATOR:

Wisconsin Geological and Natural History Survey

PROJECT CHIEF:

Charles P. Dunning

LOCATION:

Sauk County

PROJECT NUMBER:

WI 22000

PERIOD OF PROJECT:

July 2001–June 30, 2002

PROBLEM

Sauk County is under increasing development pressure, particularly in the Lake Delton/Wisconsin Dells area. Local development patterns have given rise to concerns about ground-water quality and quantity. As a result, county planners and officials recognize the increased need for knowledge of regional hydrologic conditions in order to make informed water-resource and land-use planning decisions. The purpose of this project is to conduct a comprehensive study of Sauk County's hydrogeologic resources and to delineate the zones of contribution (ZOC) for municipal wells located in the county. This project has been designed to meet the data needs of source-water protection efforts in Sauk County, and to provide technical and educational resources to promote source-water protection initiatives.

OBJECTIVE

The purpose of the Sauk County ground-water study is to understand and document the regional ground-water-flow system, as well as the local hydrologic systems around population centers, so that water resources may be managed and preserved. The specific objectives are to: (1) collect, compile, and analyze data to characterize the regional ground-water-flow system and form a conceptual hydrogeologic model, (2) quantitatively identify the zone of contribution for each municipal ground-water supply system in the county using numerical modeling techniques, and (3) encourage water-resources management and protection by introducing and promoting the use of the study products through educational and outreach efforts in Sauk County.

APPROACH

The project plan involves three phases of work.

Phase 1—Characterization of Regional Hydrogeology

Existing information will be compiled regarding the spatial distribution and hydraulic properties of hydrogeologic units; water table and potentiometric surface maps of the significant aquifer units will be constructed; a model code for a regional screening level model will be selected and calibrated to the observed

conditions; the data collection, mapping and modeling efforts will be synthesized to formulate a conceptual model of the regional hydrogeology; and a draft report prepared including the conceptual model, data, maps and study methods.

Phase 2—Delineation of Zones of Contribution

The regional screening model will be used to determine boundary conditions for "sub-models" that encompass the 13 municipal supply systems within the county; ZOC analyses will be performed for the municipal supply wells within the county; regional and sub-model development will be documented; and ZOCs will be delineated.

Phase 3—Education and Outreach

Educational and outreach materials will be prepared by selecting pertinent information from the hydrogeologic and modeling reports and working with project partners in Sauk County to identify appropriate presentation opportunities. A summary of the project findings and modeling results will be presented to local boards and civic groups.

PROGRESS (July 2001 to June 2002)

Phase 2 has been completed. Hydrologists at the USGS Wisconsin District and the Wisconsin Geological and Natural History Survey (WGNHS) have determined ZOCs for the 13 municipalities. ZOCs were determined with the use of both analytic element (single layer) and finite difference (multi-layer) models. Some stream gaging was undertaken to help quantity flux targets for the regional model as well as for the Wisconsin Dells/Lake Delton sub-model. The WGNHS is taking the lead on Phase 3 activities which are underway.

PLANS (July 2002 to June 2003)

Support will be provided to the WGNHS in completing Phase 3 as necessary.

Source: Clayton, L., and Attig, J.W., 1990, Geology of Sauk County, Wisconsin: Wisconsin Geological and Natural History Survey Circular 67, plate 1.

Major geologic features of Sauk County during the maximum late Wisconsin extent of the Green Bay Lobe. The map shows the location of the western edge of the Green Bay Lobe (arrows show direction of ice flow), outwash plains (red), and lakes (blue). The Baraboo Hills and the remainder of the Driftless Area in Sauk County are shown in shades of gray.

MENOMONEE VALLEY GROUND-WATER MODEL

COOPERATOR:

City of Milwaukee

PROJECT CHIEF:

Daniel T. Feinstein

LOCATION:

Menomonee Valley, Milwaukee

PROJECT NUMBER:

WI 22400

PERIOD OF PROJECT:

February 2001 to June 2003

PROBLEM

The City of Milwaukee and the U.S. Environmental Protection Agency (USEPA), as part of an effort to promote "brownfield" development, have funded a series of data collection and modeling studies to determine the fate of recharge to valley lands adjacent to Lake Michigan. Two major receptors exist for recharge that flows through contaminated fill—the surface-water estuary and a Deep Tunnel system constructed about 200 feet below land surface to store runoff. The overall objective of these studies is to delineate the contributing areas for these receptors in order to determine how best to evaluate potential environmental concerns.

OBJECTIVES

The objectives are to: (1) build on an existing analytical element model of the Menomonee Valley by extracting a three-dimensional MODFLOW model from the one-layer GFLOW model, (2) compare the results produced by GFLOW and MODFLOW especially with respect to the fate of recharge to the Valley, and (3) calculate travel times to receptors such as the river estuary and the ISS based on the MODFLOW results.

APPROACH

A step-wise modeling approach was used in which a regional one-layer analytic element model simulates the flow system, but also furnishes boundary conditions for a local MODFLOW model. The MODFLOW model is capable of fully addressing three-dimensional flow from the water table to the Deep Tunnel.

PROGRESS (June 2001 to June 2002)

A new water-level calibration data set corresponding to August 2001 allowed much better definition of the vertical flow regime within the MODFLOW model. The output of the updated model served to demonstrate that while both shallow and deep receptors play a role in capturing local groundwater, the Deep Tunnel is the dominant sink for water recharging the Valley. Particle tracking in conjunction with model indicated that the average travel time for water discharging to the tunnel is on the order of 80 years. This length of time is impor-

tant because it suggests that some contaminants carried by the groundwater will have sufficient time to attenuate before discharging to the Tunnel.

The ground-water model received a great deal of public attention. Several meetings were held with the Wisconsin Department of Natural Resources and the Milwaukee Journal-Sentinel to discuss the methodology and results. We were also requested by the journal Ground Water to submit an article on the modeling work (currently in review). Our results were widely distributed by the Menomonee Valley Partners, a community group interested in development of the area.

PLANS (July 2001 to June 2003)

The Milwaukee Metropolitan Sewer District has recently provided new data with respect to the amount of Tunnel infiltration that will require us to again recalibrate the model. The USEPA has agreed to provide an additional grant that will allow us to finish the modeling and produce a USGS publication, likely a Water-Resources Investigation Report. We expect to complete the analysis and the report by the end of 2002.